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Karl Iagnemma

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Massachusetts Institute of Technology (MIT)
Office of Sponsored Programs
77 Massachusetts Avenue
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14. ABSTRACT
This research has developed an "intelligent co-pilot" operator assistance algorithm for manned or teleoperated ground vehicles. A large-scale experimental study was performed on an outdoor vehicle to test the hypothesis that the semi-autonomous control framework could both prevent vehicle collisions and increase travel speed. Statistically significant results, gathered over a large population of operators, showed a substantial increase in vehicle speed and safety when guided by the semi-autonomous control framework. Other results showed an

15. SUBJECT TERMS
Ground vehicles, UGVs, control, teleoperation

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a. REPORT	b. ABSTRACT	c. THIS PAGE			Karl Iagnemma
UU	UU	UU	UU		19b. TELEPHONE NUMBER 617-452-3262

Report Title

Threat-Based Semi-Autonomous Operator Assistance Algorithms for Ground Vehicles

ABSTRACT

This research has developed an "intelligent co-pilot" operator assistance algorithm for manned or teleoperated ground vehicles. A large-scale experimental study was performed on an outdoor vehicle to test the hypothesis that the semi-autonomous control framework could both prevent vehicle collisions and increase travel speed. Statistically significant results, gathered over a large population of operators, showed a substantial increase in vehicle speed and safety when guided by the semi-autonomous control framework. Other results showed an increasing acceptance of the control technology as additional feedback modalities (i.e. visual, tactile) were provided to the operator.

Further work under this grant aimed to exploit the tools that were developed under the constraint planning work to enable a new approach to minimalistic sensing of the environment, thus resulting in a unified approach to sensing and control for ground vehicle navigation. A new algorithm for identifying and planning corridors (which approximately bound homotopic path classes) was developed. This algorithm identifies, for each homotopic path class, a minimum-length corridor (similar in nature to a road lane) from the vehicle position to some goal position. These corridors--and not the entire dense video scene--can be transmitted to a remote teleoperator to enable safe vehicle teleoperation over a degraded comms link. This work was implemented and experimentally tested (again leveraging DARPA funding) on an outdoor vehicle, and initial results suggest that comparable results for vehicle safety and travel speed were obtainable when transmitting both a dense video stream and the highly simplified corridor data, thus suggesting that the minimalistic sensing approach captures the key environmental features necessary to enable safe vehicle navigation while utilizing only a fraction of typical bandwidth requirements.

Enter List of papers submitted or published that acknowledge ARO support from the start of the project to the date of this printing. List the papers, including journal references, in the following categories:

(a) Papers published in peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in peer-reviewed journals:

(b) Papers published in non-peer-reviewed journals (N/A for none)

Received Paper

TOTAL:

Number of Papers published in non peer-reviewed journals:

(c) Presentations

Number of Presentations: 0.00

Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received	Paper

TOTAL:

Number of Non Peer-Reviewed Conference Proceeding publications (other than abstracts):

Peer-Reviewed Conference Proceeding publications (other than abstracts):

Received	Paper	
08/27/2012	1.00	Sisir Karumanchi, Karl Iagnemma. Reactive control in environments with hard and soft hazards, IEEE Intelligent Robots and Systems. 2012/10/07 00:00:00, . : ,
08/27/2012	2.00	Sterling Anderson, Sisir Karumanchi, Karl Iagnemma. Constraint-Based Planning and Control for Safe, Semi-Autonomous Operation of Vehicles, IEEE Intelligent Vehicles Symposium. 2012/06/01 00:00:00, . : ,
08/27/2012	3.00	S.J. Anderson, S. Karumanchi, B.J. Johnson, M.R. Rohde, K. Iagnemma. Constraint-based semi-autonomy for unmanned ground vehicles using local sensing, SPIE Unmanned Systems Technology XIV. 2012/04/01 00:00:00, . : ,
TOTAL:	**3**	

Number of Peer-Reviewed Conference Proceeding publications (other than abstracts):

(d) Manuscripts

Received	Paper	
08/29/2013	4.00	Sterling J Anderson, Sisir B Karumanchi, Karl Iagnemma, James M Walker. The intelligent copilot: A constraint-based approach to shared-adaptive control of ground vehicles, IEEE Intelligent transportation systems Magazine (05 2013)
08/29/2013	5.00	Sterling J Anderson, James M. Walker, Karl Iagnemma. Experimental Performance Analysis of a Constraint-Based Navigation Framework, IEEE Transactions on Systems, Man, and Cybernetics, Part A - Systems and Humans (09 2012)
TOTAL:	**2**	

Number of Manuscripts:

Books

Received	Paper
TOTAL:	

Patents Submitted

Patents Awarded

Awards

Graduate Students

NAME	PERCENT_SUPPORTED	Discipline
Sterling Anderson	1.00	
FTE Equivalent:	**1.00**	
Total Number:	**1**	

Names of Post Doctorates

NAME	PERCENT_SUPPORTED
Sisir Karumanchi	0.30
FTE Equivalent:	**0.30**
Total Number:	**1**

Names of Faculty Supported

NAME	PERCENT_SUPPORTED	National Academy Member
Karl Iagnemma	1.00	
FTE Equivalent:	**1.00**	
Total Number:	**1**	

Names of Under Graduate students supported

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Student Metrics

This section only applies to graduating undergraduates supported by this agreement in this reporting period

The number of undergraduates funded by this agreement who graduated during this period:	0.00
The number of undergraduates funded by this agreement who graduated during this period with a degree in science, mathematics, engineering, or technology fields:	0.00
The number of undergraduates funded by your agreement who graduated during this period and will continue to pursue a graduate or Ph.D. degree in science, mathematics, engineering, or technology fields:	0.00
Number of graduating undergraduates who achieved a 3.5 GPA to 4.0 (4.0 max scale):	0.00
Number of graduating undergraduates funded by a DoD funded Center of Excellence grant for Education, Research and Engineering:	0.00
The number of undergraduates funded by your agreement who graduated during this period and intend to work for the Department of Defense	0.00
The number of undergraduates funded by your agreement who graduated during this period and will receive scholarships or fellowships for further studies in science, mathematics, engineering or technology fields:	0.00

Names of Personnel receiving masters degrees

NAME
Total Number:

Names of personnel receiving PHDs

NAME
Sterling Anderson
Total Number: 1

Names of other research staff

NAME	PERCENT_SUPPORTED
FTE Equivalent:	
Total Number:	

Sub Contractors (DD882)

Inventions (DD882)

Scientific Progress

In this research program, an "intelligent co-pilot" was developed to provide operator assistance for manned and unmanned ground vehicles. A large-scale experimental study was performed on an outdoor vehicle to test the hypothesis that the semi-autonomous control framework could both prevent vehicle collisions and increase travel speed. Statistically significant results, gathered over a large population of operators, showed a substantial increase in vehicle speed and safety when guided by the semi-autonomous control framework. Other results showed an increasing acceptance of the control technology as additional feedback modalities (i.e. visual, tactile) were provided to the operator. Results from this work were covered worldwide in the popular press (100+ outlets, including Wired, Popular Science, MSNBC, New Scientist, etc.).

Further work aimed to exploit the tools that were developed under the constraint planning work to enable a new approach to minimalistic sensing of the environment, thus resulting in a unified approach to sensing and control for ground vehicle navigation. A new algorithm for identifying and planning corridors (which approximately bound homotopic path classes) was developed. This algorithm identifies, for each homotopic path class, a minimum-length corridor (similar in nature to a road lane) from the vehicle position to some goal position. These corridors--and not the entire dense video scene--can be transmitted to a remote teleoperator to enable safe vehicle teleoperation over a degraded comms link. This work was implemented and experimentally tested (again leveraging DARPA funding) on an outdoor vehicle, and initial results suggest that comparable results for vehicle safety and travel speed were obtainable when transmitting both a dense video stream and the highly simplified corridor data, thus suggesting that the minimalistic sensing approach captures the key environmental features necessary to enable safe vehicle navigation while utilizing only a fraction of typical bandwidth requirements.

Technology Transfer